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Efficacy of DAA-based Antiviral Therapies for HCV Patients with Chronic Kidney Disease: A Meta-analysis

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Authors' contributions

This work was carried out in collaboration among all authors. Authors Peyman Sanjari Pirayvatlou, SMA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SSP and Pouyan Sanjari Pirayvatlou managed the analyses of the study. Authors MM and ME managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Context: HCV infection in patients with chronic kidney disease (CKD) is important to be treated because it's associated with increased healthcare costs, utilization and is pertained with decrease in survival rate of HCV-infected patients who also have chronic kidney disease. Direct acting agents (DAAs) are novel form of treatment of HCV infection in patients with CKD. The aim of this study is meta-analysis and comparison of the efficacy of different regimen of DAAs used in the treatment of HCV in such patients.

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Objective: Hepatitis C is a liver disease caused by the hepatitis C virus, the virus can cause both acute and chronic hepatitis. Hepatitis C virus (HCV) is a known risk factor for chronic kidney disease (CKD) and end-stage renal disease (ESRD). HCV infection in CKD patients is also associated with increased healthcare costs and utilization, with further increases in those with ESRD. It should be also noted that survival among HCV-infected patients with chronic kidney disease without undertaking any treatment is low, various mechanisms such as increased liver-related mortality, low quality of life and high cardiovascular risk can explain this finding. The benefits of treatment may extend beyond the liver, with improvements in both cardiovascular and renal outcomes in patient with chronic kidney disease. Previously PEG-INTERFRON Based regimens have been used for treatment of CKD or ESRD Patients with chronic Hepatitis C but this treatment plan was associated with higher adverse effects and less efficacy. Nowadays new researches have shown the efficacy of the Direct Anti-Viral Agents (DAAs) In such patients.

Data Sources: A systematic literature searches in PubMed, EMBASE, Web of Science, and Scopus motor searches was done. Virologic response at 12 weeks after the end of treatment (SVR12) was extract from the included studies. Finally, SVR12 rate with 95% confidence intervals (CI) were pool analyzed with random-effects model.

Study Selection: Studies were included if they satisfied the following criteria: Participants being adult HCV patients with stage 3–5 CKD (age≥18 years), Interventions being DAA-based antiviral therapies, Outcomes being sustained virologic response at 12 weeks after the end of treatment (SVR12). Studies were excluded if having incomplete outcome data and had no sufficient data to calculate SVR12.

Data Extraction: The methodological quality of included observational studies was assessed by three reviewers independently by using the Newcastle–Ottawa scale (NOS), which is usually used for observational studies in meta-analyses.

Results: 20 studies comprising a total of 628 patients (from 20 studies) were included for our meta-analysis. The pooled analysis for SVR12 rate was 0.95 (95% CI 0.92-0.96, I^2= 0.00%), 0.92 (95% CI 0.82-0.96 I^2= 0.00%) and 0.95 (95% CI 0.93-0.97, I^2= 0.0%) for total population, sofosbuvir base treatment group and non sofosbuvir base treatment group.

Conclusion: DDAs have high efficacy in treatment of HCV in patient with CKD and it seems that there is no different between sofosbuvir versus non sofosbuvir based regimens for treatment of HCV infection in this patients.

Keywords: CKD; ESRD; HCV; DAA; SVR.

1. INTRODUCTION

Hepatitis C is a liver disease caused by the hepatitis C virus, the virus can cause both acute and chronic hepatitis and it's a blood borne virus and the most common modes of infection are through exposure to small quantities of blood. Nowadays the prevalence of HCV infection in the world varies from 0.5% to 1.0% and the most affected regions are WHO Eastern Mediterranean and European Regions, with the prevalence of 2.3% and 1.5% respectively. Globally, an estimated 71 million people have chronic hepatitis C infection and approximately 399000 people die each year from hepatitis C, mostly from cirrhosis and hepatocellular carcinoma [1]. In the other hand hepatitis C virus (HCV) is a known risk factor for chronic kidney disease (CKD) and end-stage renal disease (ESRD) [2]. HCV infection in CKD patients is also associated with increased healthcare costs and utilization, with further increases in those with ESRD [3]. Various mechanisms could explain the reduced survival among HCV-infected patients with chronic kidney disease (CKD): increased liver-related mortality, impaired quality of life, and higher cardiovascular risk. The HCV Kidney Disease: Improving Global Outcomes (KDIGO) workgroup has already recommended the treatment of those HCV-infected patients, dialysis dependent or not, in the waiting list for renal transplant [4,5]. The benefits of treatment may extend beyond the liver, with improvements in both cardiovascular and renal outcomes in patient with chronic kidney disease [6]. Some studies clarify the importance of antiviral therapy in HCV-infected patients with impaired renal function, especially in patients with stage 4–5 chronic kidney disease (CKD), which is defined as glomerular filtration rate (GFR) ≤30 ml/min/1.73 m2 or on dialysis [7-10]. Despite the benefits of viral eradication, in the interferon (IFN) era, the use of antiviral treatment in patients with CKD was hampered by the high number of adverse events related to therapy, especially anemia and infections [11]. So the

rapidly expanding repertoire of direct-acting antiviral agents (DAA) to treat and cure HCV in the general population appears to offer hope to HCV infected CKD patients as well [12]. The development of direct-acting antivirals (DAAs) has completely changed the scenario enabling the treatment of more difficult patients including those with ESRD. The advantages of DAAs in patients with ESRD are [1] the increase in the efficacy results, [2] the improvement in safety, and [3] the possibility to treat the patients after kidney transplantation [11]. In this study we compared the efficacy of different regimen of DDAs to treatment of HCV infection in patients with chronic kidney disease.

1.1 Data Resources

Three reviewers conducted a systematic literature search in PubMed, EMBASE, Web of Science, and Scopus motor searches. There was no time or language limitation. The search strategy used was "(Chronic kidney disease OR chronic kidney failure OR severe renal impairment OR End stage renal disease OR dialysis) AND (sofosbuvir OR ledipasvir OR simeprevir OR grazoprevir OR elbasvir OR ombitasvir OR paritaprevir OR ritonavir OR dasabuvir OR daclatasvir OR asuparevir OR direct-acting antiviral OR DAA)". We carefully checked the titles, abstracts and full text of all returned articles. References listed in these articles were also reviewed. The search strategy was lastly updated on 30 November 2018.

1.2 Study Selection

Studies were included if they satisfied the following criteria: Participants: adult HCV patients with stage 3–5 CKD (age≥18 years), Interventions: DAA-based antiviral therapies, Outcomes: Sustained virologic response at 12 weeks after the end of treatment (SVR12). Studies were excluded were Studies with incomplete outcome data and there was no sufficient data to calculate SVR12.

1.3 Data Extraction

Based on the PRISMA guideline for reporting of systematic review, all papers from search results were independently reviewed by three people at each level of screening (title, abstract and full-text) [13]. The methodological quality of included observational studies was assessed by three authors independently by using the Newcastle–Ottawa scale (NOS), which was usually used for observational studies in meta-analyses [14]. In this scale, observational studies were scored across 3 categories: selection (up to 4 points), comparability (up to 2 points) and exposure or outcome of study participants (up to 3 points). Studies with a cumulative score 7 or more were considered as high quality, and studies with cumulative scores 4-6 were defined as fair quality. Data that extract from the studies were include: Publication year, first author, number of included patients, treatment strategy, study design and sustained virologic response at 12 weeks after the end of treatment (SVR12).

1.4 Data Analysis

Finally, SVR12 rate with 95% confidence intervals (CI) were pooled with random-effects model. Heterogeneity was examined by I2 index, and was considered significant if I2 value was 50% and greater. The P value was used to compare the above parameters in subgroup analyses and its significant if ≤ 0.05. All statistical analyses were performed by using the statistical software Comprehensive meta-analysis V3.

2. RESULTS

2.1 Study Screening

A total of 722 potentially relevant articles were returned through the preliminary literature search, and 702 articles were excluded because of duplicates, inappropriate for inclusion criteria or be irrelevant. Finally, 20 studies comprising a total of 628 patients were included for our meta-analysis (Fig. 1).

2.2 Risk of Bias Assessment

All included studies were categorized as high quality (with taking a score of more than 7) and therefore no studies were excluded based on the quality assessment.

2.3 Characteristics of the Included Studies

Based on the goal of study the characteristics (publication year, first author, number of included patients, treatment strategy, study design and sustained virologic response at 12 weeks after the end of treatment) of 20 studies are shown in Table 1. From 20 studies that included for meta-analysis, 13 studies were on non-Sofosbuvir-based treatment. 12 study was case series and 8 was clinical trial. Two study was in stage 5 of CKD and one was in stage 3-5 and other studies was in stage 4-5 of CKD.

2.4 Evaluation of Treatment Outcome

We calculated pooled SVR12 for four HCV treatment regimens including 12 weeks of Sofosbuvir-based (A) and 12 weeks of non Sofosbuvir-based (B). Summary of results of these meta-analyses have been shown in the Table 2.

- **Treatment regimen A:**
  7 studies were found which evaluated regimen A. The pooled SVR12 for this regimen based on random-effect model was calculated as 0.92 (95% CI 0.82-0.96 I^2= 0.0%). More details in Fig. 2.

- **Treatment regimen B:**
  13 studies were found which evaluated regimen B. The pooled SVR12 for this regimen based on random-effect model was calculated as 0.95 (95% CI 0.93-0.97, I^2= 0.0%). More details in Fig. 3.

Finally, the P value between SVR12 rates of sofosbuvir (A) versus non-sofosbuvir (B) base regimen groups was (p=0.197).

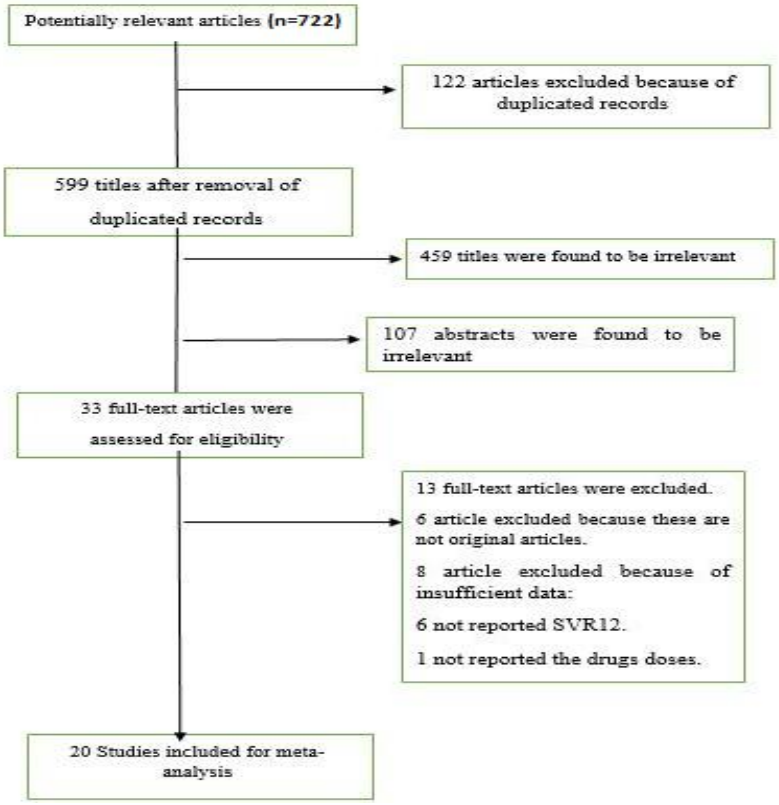

Fig. 1. The flow diagram of literature review and studies selection

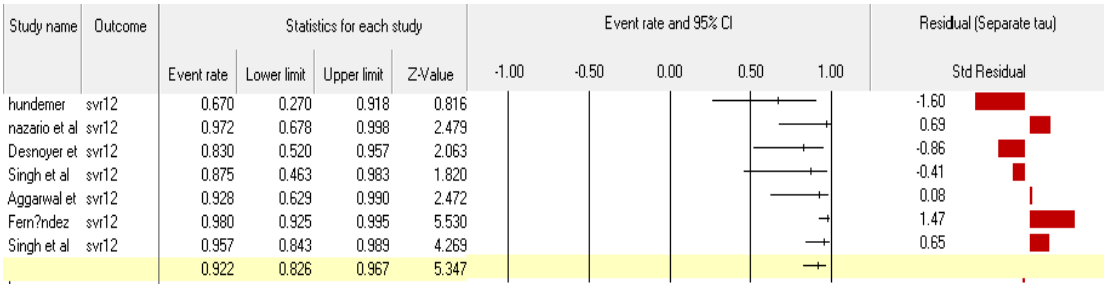

Fig. 2. The pooled SVR12 for regimen A based on random-effect model

Table 1. Characteristics of studies that included for meta-analysis

Author/year	Type of study	Number of patients	Regimen	CKD stage	SVR 12 (%)
Roth, et al. [8].	Clinical trial	111	grazoprevir (100 mg) + elbasvir (50 mg) daily	Stage 4 and 5	99% (95% CI 95·3–100·0; 115/116)
Pockros, et al. [15].	Clinical trial	20	ombitasvir + paritaprevir + ritonavir (25/150/100 mg) daily + dasabuvir (250 mg) twice daily ± ribavirin (200 mg) daily	Stage 4 and 5	90% (95% CI 69.9–97.2)
Hundemer, et al. [16].	Case series	6	sofosbuvir (400 mg) daily + simeprevir (150 mg) daily (n=3), Sofosbuvir (400 mg) daily + ribavirin (200 mg) twice daily (n=2), sofosbuvir (400 mg) daily + ribavirin (600 mg) twice daily + PEG-IFN (180 mcg) SC weekly	Stage 4 and 5	67% (4/6) (95% CI not reported)
Nazario, et al. [9].	Case series	17	sofosbuvir (400 mg) daily + simeprevir (150 mg) daily	Stage 4 and 5	100% (17/17) (95% CI not reported)
Gane, et al. [17].	Clinical trial	18	ombitasvir + paritaprevir + ritonavir (25/150/100 mg) daily + dasabuvir (250 mg) twice daily (n=13), ombitasvir + paritaprevir + ritonavir (25/150/100 mg) daily (n=5)	Stage 4 and 5	Total 94% (95% CI 74-99 17/18) 100% for (95% CI 77-100 13/13)
Gane, et al. [18].	Clinical trial	104	glecaprevir (300 mg) + pibrentasvir (120 mg) daily	Stage 4 and 5	98% (95% CI not reported)
Toyoda, et al. [19].	Clinical trial	28	daclatasvir (60 mg) daily + asunaprevir (100 mg) twice daily	Stage 5	100% (95% CI not reported)
Desnoyer, et al. [20].	Clinical trial	12	Sofosbuvir (400 mg) daily (n=7), Sofosbuvir (400 mg) 3 times in week (n=5) both + daclatasvir (n=8) or simeprevir (n=2) or ledipasvir (n=1) or ribavirin (n=1)	Stage 5	100% (95% CI not reported) 60% (95% CI not reported) All 83% (10/12)
Monuz-gomez, et al. [21].	Case series	46	ombitasvir + paritaprevir + ritonavir (25/150/100 mg) + ribavirin (200 mg) daily (n = 3), ombitasvir + paritaprevir + ritonavir (25/150/100 mg) daily + daclatasvir (250 mg) twice daily (n=25) ombitasvir + aritaprevir + ritonavir (25/150/100 mg) + daclatasvir (250 mg) twice daily + ribavirin (200 mg) daily (n = 18)	Stage 4 and 5	95.7% (44/46) (95% CI not reported)
Sato, et al. [22].	Case series	4	ombitasvir + paritaprevir + ritonavir (25/150/100 mg) daily	Stage 4 and 5	75% (3/4) (95% CI not reported)
Ponziani, et al. [23].	Case series	10	ombitasvir + paritaprevir + ritonavir (25/150/100 mg) daily + daclatasvir (250 mg) twice daily (n=8), ombitasvir + paritaprevir + ritonavir (25/150/100 mg) + daclatasvir (250 mg) twice daily + ribavirin (200 mg) daily (n =2)	Stage 4 and 5	100% (10/10) (95% CI not reported)
Welzel, et al. [24].	Case series	9	ombitasvir + paritaprevir + ritonavir (25/150/100 mg) daily ± daclatasvir (250 mg) twice daily ± ribavirin (1200 mg or 1000 mg) divided into two daily doses	Stage 4 and 5	100% (9/9) (95% CI not reported)
Singh, et al. [25].	Clinical trial	8	Sofosbuvir (400 mg) + simeprevir (150 mg) daily (n=4), Sofosbuvir (400 mg) + ledipasvir (90 mg) daily (n=4)	Stage 4 and 5	87.5% (7/8) (95% CI not reported)

Author/year	Type of study	Number of patients	Regimen	CKD stage	SVR 12 (%)
Aggarwal, et al. [26].	Case series	14	Sofosbuvir (400 mg) daily + Simeprevir (150 mg) daily (n=6), Sofosbuvir (400 mg) daily + ledipasvir (90 mg) daily (n=3), Sofosbuvir (400 mg) daily + ribavirin (200 mg) daily (max dose) (n=2), Sofosbuvir (400 mg) daily + daclatasvir (250 mg) twice daily (n=1), Sofosbuvir (400 mg) daily + ribavirin (200 mg) daily (max dose) + pegylated interferonalpha (n=1)	Stage 4 and 5	92.8% (13/14) (95% CI not reported)
Sperl, et al. [27].	Case series	23	ombitasvir + paritaprevir + ritonavir (25/150/100 mg) daily + asabuvir (250 mg) twice daily ± ribavirin	Stage 4 and 5	100% (23/23) (95% CI not reported)
Singh, et al. [28].	Case series	46	Sofosbuvir (400 mg) daily ± Ledipasvir (90 mg) daily or/and aclatasvir (60 mg) daily	Stage 4 and 5	95.7% (45/46) (95% CI not reported)
Suda, et al. [29].	Clinical trial	21	Dataclatavir (60 mg) daily +Asunaprevir (100 mg) twice daily	Stage 4 and 5	95.5% (20/21) (95% CI not reported)
Miyazaki, et al. [30].	Case series	10	Dataclatavir (60 mg) daily +Asunaprevir (100 mg) twice daily	Stage 4 and 5	100% (10/10) (95% CI not reported)
Kawakami, et al. [31].	Case series	18	Dataclatavir (60 mg) daily +Asunaprevir (100 mg) twice daily	Stage 4 and 5	100% (18/18) (95% CI not reported)
Fernández, et al. [32].	Case series	103	Sofosbuvir + ledipasvir (n=30), Sofosbuvir + ledipasvir + ribavirin (n=29), Sofosbuvir + daclatasvir (n=16), Sofosbuvir + daclatasvir + ribavirin (n=2), ombitasvir + paritaprevir + ritonavir + daclatasvir (n=8), ombitasvir + paritaprevir + ritonavir + daclatasvir + ribavirin (n=2), Sofosbuvir + simeprevir (n=5), Sofosbuvir + simeprevir + ribavirin (n=3), simeprevir + daclatasvir (n=2), simeprevir + daclatasvir + ribavirin (n=4), sofosbuvir + ribavirin (n=2)	Stage 3, 4 and 5	98% (101/103) (95% CI not reported)

Table 2. Summary of meta-analyses of the sustained virologic response rate for sofosbuvir base (A) versus non sofosbuvir base (B) regimen

Regimen	Sofosbuvir use	Treatment duration (Wks)	SVR12 rate (%)	95%CI (%)
A	yes	12	92	82-96
B	No	12	95	93-97

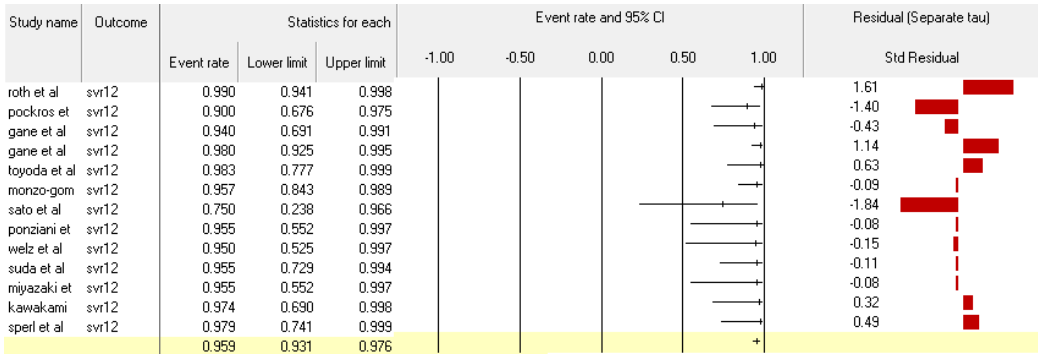

Fig. 3. The pooled SVR12 for regimen B based on random-effect model

3. CONCLUSION

As we know HCV is thought to trigger an immune cascade that attacks the kidneys, resulting in glomerulonephritis and in the other hand HCV infection in patients with CKD is associated with renal disease progression, and those with more severe CKD have a higher rate of positive anti-HCV antibodies [33,34]. Also survival among HCV-infected patients with chronic kidney disease without treatment is low and various mechanisms could explain it like increased liver-related mortality, impaired quality of life and higher cardiovascular risk [5]. Unfortunately, until recently, patients with chronic HCV infection and advanced CKD (estimated glomerular filtration rate GFR ≤30 mL/min/1.73 m2 or dialysis) had few safe and effective HCV treatment options. Therapy with standard interferon (IFN) or pegylated IFN was associated with poor tolerability and low SVR rates but nowadays we use DDAs for treatment of HCV infection in patient with CKD [35]. So any patient with renal insufficiency should be offered treatment with DAAs in order to reduce the risk of progression in liver disease and also renal related morbidity and mortality, especially after transplantation. Eradication of HCV also reduces the risk of cardiovascular disease, diabetes, extra hepatic cancers and improves their quality of life [36]. First time in 2011 first-generation (DAA) telaprevir and boceprevir became available and needed to be associated with PEG-IFN and RBV although Such triple therapy was reported as feasible but was not extensively evaluated (and, thus, probably not used) because of major concerns about tolerability, especially the risk of anemia. After that Second-generation DAA became available in 2013, initially including sofosbuvir, daclatasvir and simeprevir. Until now, SOF has been the backbone of new antiviral regimens and has been used as part of combination therapy with IFN and/or RBV, or in IFN/RBV-free regimens [37,38]. Recent meta-analysis (2016) shows that non sofosbuvir based regimen has high efficacy in treatment of HCV infection in patient with CKD [39]. In addition it is thus essential that we carefully select the most appropriate DAA regimen and the best time for treatment, while sofosbuvir, has been the backbone of most pangenotypic therapeutic regimens, it has a limitation in those with advanced kidney disease [35]. So because of insufficient knowledge about best DDAs regimens in patient with chronic kidney disease we did this study and include 20 studies to our meta-analysis. 628 patients were evaluated in our study and pooled analysis for SVR12 rate for DDAs in treatment of HCV infection in patient with CKD was 0.95 with low heterogeneity (I^2= 0.00%). In sofosbuvir base regimen, sofosbuvir were combined with Elbasvir, grazoprevir, ribavirin, ledipasvir and daclatasvir. The dose of sofosbuvir was 400 mg daily or 400 mg three times a week. The SVR12 rate for sofosbuvir base treatment group was 0.92 with low heterogeneity (I^2= 0.00%). In the other hand in non sofosbuvir base treatment elbasvir, glecaprevir, pibrentasvir, ribavirin, Asunaprevir, ombitasvir, paritaprevir, ritonavir and Dasabuvir

were used. The SVR12 rate for this group was 0.95 with low heterogeneity (I^2= 0.0%). From the results the P value between SVR rates of sofosbuvir versus non-sofosbuvir base treatment groups were (p=0.197). In conclusion, our meta-analysis evaluated the efficacy of DDAs regimens in treatment of HCV infection in patient with chronic kidney disease. From the results DDAs has high efficacy in treatment of HCV in patient with CKD. In comparison the different regimen of DDAs, the non sofosbuvir base regimen showed no significant different versus sofosbuvir base regimen. In this meta-analysis it seems that DDA regimen is the best choice for treatment of HCV infection in patient with chronic kidney disease.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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